CLAIMS

1. A method of scanning for writing a pattern on a surface, comprising:

providing a scanning beam comprised of a plurality of independently addressable sub-beams;

scanning the surface with said scanning beam a plurality of times, said sub-beams scanning the surface side-by side in the cross-scan direction, each said sub-beam being modulated to reflect information to be written; and

overlapping the beams such that all written areas of the surface are written on during at least two scans.

2. A method according to claim 1 wherein said written areas are written on at least three times.

3. A method according to claim 1 wherein said written areas are written on at least four times.

4. A method according to claim 1 wherein said written areas are written on at least six times.

5. A method according to claim 1 wherein said written areas are written on at least eight times.

6. A method according to claim 1 wherein said written areas are written on at least twelve times.

7. A method according to claim 1 wherein said written areas are written on at least twenty four times.

8. A method according to claim 1 ~~any of the preceding claims~~ wherein the beam is formed by separately modulating individual segments of an oblong beam, said segments comprising said sub-beams.

9. A method according to claim 8 wherein separately modulating comprises:

providing an oblong beam having a usable extent in the long direction; and

providing a plurality of modulation segments along said long direction, the total extent of said segments being greater than the usable extent.

10. A method according to claim 1 ~~any of claims 1-7~~ wherein the sub-beams are separately produced and including combining the sub-beams to form said beam.

11. A method according to claim 1 ~~any of the preceding claims~~ wherein the unmodulated energy of at least two of the separately addressable sub-beams is different.

12. A method according to claim 11 wherein the unmodulated energy has a generally Gaussian profile.

13. A method according to claim 11 ~~or claim 12~~ wherein the modulation of the beam is binary, on-off modulation.

14. A method according to claim 1 ~~any of the preceding claims~~ wherein a pattern having a minimum feature size is written and wherein the spacing of the sub-beams is substantially smaller than the feature size.

15. A method according to claim 14 wherein the minimum feature size is at least four times as large as the extent of the sub-beams.

16. A method according to claim 14 ~~or claim 15~~ wherein the minimum feature size is less than or equal to about 77 micrometers.

17. A method according to claim 14 ~~or claim 15~~ wherein the minimum feature size is less than or equal to about 51 micrometers.

18. A method according to claim 14 ~~or claim 15~~ wherein the minimum feature size is less than or equal to about 39 micrometers.

19. A method according to claim 1 ~~any of the preceding claims~~ wherein the sub-beams are spaced by a predetermined distance at said surface and wherein the sub-beams have an extent at the surface in the direction of adjacent beams and wherein the extent is greater than the spacing.

20. A method according to claim 19 wherein the spacing is less than about 15 micrometers.

21. A method according to claim 19 wherein the spacing is less than about 10 micrometers.

22. A method according to claim 19 wherein the spacing is about 6.35 micrometers.

23. A method according to claim 19 wherein the spacing is less than about 6.35 micrometers.

24. A method according to claim 19 ~~any of claims 19-23~~, wherein the extent is at least twice the spacing.

25. A method according to claim 24 wherein the extent is at least three times the spacing.

26. A method according to claim 19 ~~any of claims 19-25~~ wherein the extent is more than about 6.35 micrometers.

27. A method according to claim 19 ~~any of claims 19-25~~ wherein the extent is greater than or equal to about 12.7 micrometers.

28. A method according to claim 19 ~~any of claims 19-25~~ wherein the extent is greater than or equal to about 19 micrometers.

29. A method according to claim 19 ~~any of claims 19-25~~ wherein the extent is greater than or equal to about 25.4 micrometers.

30. A method of optimizing throughput in a scanning system while selectively delivering a variable desired level of energy to the surface, comprising:

scanning a surface in accordance with claim 1 ~~any of the preceding claims~~ to provide exposed areas and unexposed areas in accordance with modulation of the sub-beams;

providing said beam at a given optimized power;

determining a combination of parameters including (1) beam scanning velocity between a maximum and minimum velocity, said maximum and minimum velocities defining a scanning velocity ratio; (2) a speed of relative movement of the surface and the beams in a direction normal to the scan; and (3) a beam overlap suitable for exposing the exposed surface areas to the desired energy with the beam at optimized power; and

exposing the surface utilizing the determined combination of parameters.

31. A method according to claim 30 and including:

selectively varying the energy delivered to exposed areas on the board by a ratio substantially greater than the scanning velocity ratio, by varying the parameters.

32. A method of optimizing throughput in a scanning system while selectively delivering a variable desired level of energy to the surface, comprising

providing a beam at a given optimized power;

modulating the beam;

scanning the beam across the surface in a first direction with a first velocity, between a maximum and minimum velocity, said maximum and minimum velocities defining a scanning velocity ratio;

relatively moving the surface and the scanning beam on a second direction normal to the first direction at a second velocity; and

selectively varying the energy delivered to exposed areas on the board by a ratio substantially greater than the scanning velocity ratio.

33. A method according to ~~claim 31 or~~ claim 32 wherein the energy delivered is varied by a factor at least one and on-half times as high as the scanning velocity ratio.

34. A method according to claim 33 wherein the energy delivered is varied by a ratio at least three times as high as the scanning velocity ratio.

35. A method according to claim 33 wherein the energy delivered is varied by a ratio at least five times as high as the scanning velocity ratio.

36. A method according to claim 33 wherein the energy delivered is varied by a ratio at least ten times as high as the scanning velocity ratio.

37. A method according to ~~any of claims 31-36~~ claim 32 wherein the scanning velocity ratio is no greater than 1.5.

38. A method according to ~~any of claims 31-37~~ claim 32 wherein the scanning velocity ratio is no greater than 2.

39. A method of determining the position of a surface in relation to a scanning beam in a scanner, the method comprising:

providing the surface with at least two holes;

scanning the surface at least in the vicinity of the holes with the beam;

detecting the beam when it is in positions at which it passes through the holes;

determining positions, in a scanner reference frame, of the beam at least at those positions where the beam is at an edge of the hole; and

determining the positions of the holes, in the scanner reference frame, based on a determination of the positions of the edges of the holes.

40. A method according to claim 39 wherein the position of the edges of the hole are determined over the entire circumference of the holes.

41. A method according to claim 39 or claim 40 and including:

determining a distance between the two holes;

comparing the determined distance to a design distance; and

determining a scaling factor for data to be written on the surface by the scanner from said comparison.

42. A method according to claim 41 and further including:

providing at least one additional hole in the surface positioned non-colinearly with the at least two holes;

determining the position of the at least one additional hole;

determining a further distance between the at least one additional hole and at least one of the at least two holes;

comparing said further distance with a design further distance; and

determining at least one scaling factor for data to be written on the surface by the scanner from said comparison of the further distance and the design further distance.

43. A method according to claim 42 wherein determining the position of a hole comprises determining the positions of points on the edge of the hole and computing the position of the center of the hole based on the determined positions of the edge positions.

44. A method according to any of claims 39-43 and including:

comparing the positions of the holes to a design position.

45. A method according to claim 44 and including:

correcting one or both of the position of the surface and the positioning of data to be written on the surface based on said comparison.

46. A method according to claim 45 wherein correcting comprises rotating the surface.

47. A method according to claim 45 wherein correcting comprises rotating the data.

48. A method according to any of claims 45-47 wherein correcting comprises translating the relative positions of the surface or the data.

49. A method according to any of claims 45-48 and including:

correcting the size of data to be written on the surface based on said comparison.

50. A method according to any of claims 39-49 wherein detecting comprises detection utilizing a same detector for a plurality of holes, wherein the detector receives energy passing through the holes via a light-guide.

51. A method according to claim 50 wherein light is transmitted to the detector from a plurality of holes, via a same light guide.

52. A method according to any of claims 39-48 wherein detecting comprises detecting utilizing a different detector for different holes.

53. A method according to any of claims 39-51 wherein the surface is determined from the position of the at least one hole.

54. A method according to claim 53 wherein the at least two holes comprise at lest three asymmetrically placed holes and wherein the side of the surface is determined from the relative positions of the holes.

55. A method of writing data in a scanner type writing system, comprising:
providing data for writing on a surface;
measuring the position of at least two features on a surface;
comparing a distance between the features to a design distance;
scaling the data based on the comparison; and
writing the scaled data on the surface.

56. A method according to claim 55 wherein measuring comprises measuring the position of at least three non-collinear features and wherein scaling comprises scaling in two directions with different scale factors.

57. A method according to claim 55 or claim 56 wherein the features are through holes.

58. A method according to any of the preceding claims wherein the surface is the surface of a metalized printed circuit board substrate coated with a photoresist material.

59. A method of accommodating different thicknesses of printed circuit boards in a scanning type direct writing exposure system for printed circuit boards, comprising:

providing a metalized printed circuit board substrate coated with a photoresist material having a given thickness; and

focusing a scanning beam on the photoresist material by changing the focus plane of the scanning beam.

60. A method according to claim 59 wherein the beam scans in a scanning direction and has a first extent in the scanning direction and a second, different, extent in the cross-scanning direction and including focusing the scanning beam in both directions at said surface.

61. A method according to claim 60 wherein:

scanning comprises:

providing an prescanned beam to a scanning element; and

focusing comprises:

determining a common focus point for the scan and cross-scan directions of the prescanned beam; and

changing the common focus point to effect focusing of the scanning beam on the coating.

62. A method according to claim 61, wherein changing the common focus point comprises changing the position of a lens.

63. A method according to claim 62 wherein changing the position comprises changing the position of a single lens.

64. A method according to any of claims 61-63 wherein providing a prescanned beam comprises separately modulating a plurality of beam segments disposed in the cross-scan direction and wherein the modulated prescanned beam is in substantially in focus in both scan and cross scan directions for only a portion of its path.

65. A method according to claim 64 wherein the portion comprises substantially a point.

66. Apparatus for scanning a beam across a surface, comprising:

a first beam;

a modulator that receives a light beam at an optical input thereof, and produces a modulated light beam at an exit thereof, based on a modulation signal thereto;

a second beam;

a scanner that receives the first and second beams and scans the first beam across the surface and the second beam along a path substantially parallel to the path of the first beam; and

a controller that provides said modulation signal responsive to the position of the second beam,

A wherein ~~characterized in that~~:

the first and second beams have substantially the same wavelengths.

67. Apparatus according to claim 66 wherein the first beam includes energy at a wavelength different from the wavelength of the second beam.

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68. Apparatus according to claim 66 ~~or claim 67~~ and including:

a marked scale upon which the second beam impinges, such that the second beam is reflected therefrom to form a modulated reflected beam.

69. Apparatus according to claim 68 wherein the second beam impinges the scale at an angle to its surface, such that the modulated reflected beam is reflected along an axis, different from that of the second beam.

70. Apparatus for scanning a beam across a surface, comprising:

a first beam;

a modulator that receives a light beam at an optical input thereof, and produces a modulated light beam at an exit thereof, based on a modulation signal thereto;

a second beam;

a scanner that receives the first and second beams and scans the first beam across the surface and the second beam along a path substantially parallel to the path of the first beam;

a controller that provides said modulation signal responsive to the position of the second beam; and

a marked scale upon which the second beam impinges, such that the second beam is reflected therefrom to form a modulated reflected beam,

characterized in that:

the second beam impinges the scale at an angle to its surface, such that the modulated reflected beam is reflected along an axis, different from that of the second beam.

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71. Apparatus according to claim 70 ~~any of claims 66-70~~ wherein the scanner comprises:

a scan device that receives a beam along a first axis and periodically rotates the beam axis to form a rotating beam; and

an optical system that translates the periodic rotation into periodic lineal scanning of the beam,

wherein the first and second beams are both scanned utilizing the scan device and the optical system.

72. Apparatus according to claim 71 wherein the power of said beam varies as the beam axis rotates, wherein the optical system includes a quasi f-θ lens system that varies the lineal speed of the linear scanning to compensate for the power variations.

73. Apparatus for scanning a beam across a surface, comprising:

a first beam;

a modulator that receives a light beam at an optical input thereof, and produces a modulated light beam at an exit thereof, based on a modulation signal thereto;

a second beam;

a scanner that receives the first and second beams and scans the first beam across the surface and the second beam along a path substantially parallel to the path of the first beam, the scanner comprising:

a scan device that receives a beam along a first axis and periodically angularly shifts the beam axis to form a rotating beam; and

an optical system that translates the periodic rotation into periodic linear scanning of the beam; and

a controller that provides said modulation signal responsive to the position of the second beam;

A wherein ~~characterized in that~~: the first and second beams are both scanned utilizing the scan device and the optical system.

74. Apparatus according to claim 73 wherein the optical system comprises a quasi-f-θ lens that provides non-linear tracking of linear beam position and angle.

A 75. Apparatus according to claim 73 ~~any of claims 66-74~~ and including a marked scale upon which the second beam impinges, such that the second beam is reflected therefrom to form a modulated reflected beam.

76. Apparatus according to claim 75 wherein the second beam impinges the scale at an angle to its surface, such that the modulated reflected beam is reflected along an axis, different from that of the second beam.

77. Apparatus for scanning a beam across a surface, comprising:

a first beam;

a modulator that receives a light beam at an optical input thereof, and produces a modulated light beam at an exit thereof, based on a modulation signal thereto;

a second beam;

a scanner that receives the first and second beams and scans the first beam across the surface and the second beam along a path substantially parallel to the path of the first beam;

a controller that provides said modulation signal responsive to the position of the second beam; and

a marked scale upon which the second beam impinges, such that the second beam is reflected therefrom to form a modulated reflected beam,

wherein ~~characterized in that~~:

the second beam impinges the scale at an angle to its surface, such that the modulated reflected beam is reflected along an axis, different from that of the second beam.

78. Apparatus according to claim 77 ~~any of claims 75-77~~ wherein the controller provides said modulation, based on the modulations of the reflected beam.

79. Apparatus according to claim 77 ~~any of claims 75-78~~ and including a detector that receives said modulated reflected beam and generates a modulated signal therefrom, said controller providing said modulation, based on timing of said modulated signal.

80. Apparatus according to claim 79 wherein the controller includes:

a clock generator that receives the modulated signal and generates a timing clock having a clock frequency that is controllably related to the frequency of the modulated signal.

81. Apparatus according to claim 80 wherein the clock generator includes:

a first generator that generates an intermediate clock and an inverse intermediate clock having the same frequency and inverse phases; and

switching circuitry having two inputs that receive the intermediate clock and the inverse intermediate clock respectively and a timing clock output to which the clock at one of the two inputs is selectively switched, such that the average frequency of the timing clock at the output is controlled by said selective switching.

82. Apparatus according to claim 81 wherein the switching circuitry switches said inputs to said output responsive to clock correction information.

83. Apparatus according to claim 80 ~~any of claims 80-82~~, and including:

a data store containing stored modulation information, which passes said information to said modulator for modulating the first beam, based on timing of said stable clock.

84. Apparatus for scanning a beam across a surface, comprising:

a modulated beam

a scanner that receives the modulated beams and scans it across the surface, the scanner comprising:

a scan device that receives a beam along a first axis and periodically rotates the beam axis to form a rotating beam; and

an optical system that translates the periodic rotation into periodic linear scanning of the beam;

wherein ~~characterized in that~~ the optical system comprises a quasi-f-θ lens that provides non-linear tracking of linear beam position and angle, to compensate for variations of power in the beam as a function of angle.

85. Apparatus according to claim 84 and including:

a modulator that receives a light beam at an optical input thereof, and produces the modulated light beam at an exit thereof, based on a modulation signal thereto;

a second beam, wherein the scanner receives the modulated and second beams and scans the second beam along a path substantially parallel to the path of the modulated beam; and

a controller that provides said modulation signal responsive to the position of the second beam.

86. Apparatus according to claim 85 and including a marked scale upon which the second beam impinges, such that the second beam is reflected therefrom to form a modulated reflected beam.

87. Apparatus according to claim 86 wherein the second beam impinges the scale at an angle to its surface, such that the modulated reflected beam is reflected along an axis, different from that of the second beam.

88. Apparatus according to claim 85 ~~or claim 86~~ wherein the markings on the scale are non-uniform to correct for systematic differences between the positions of the modulated and second beams.

89. Apparatus for holding flat plates of varying sizes and having, comprising:

a base section having a flat surface and including plurality of interconnected channels formed on the surface thereof;

at least one port connecting to said channels;

a vacuum source connected to the at least one port;

an intermediate plate covering all of said channels and having a multiplicity of holes formed therethrough, that are present only in areas of the flat surface without holes.

90. Apparatus according to claim 89 wherein at least a portion of the base section comprises an array of truncated pyramids, flat tops of said pyramids comprising the flat surface and areas between the pyramids comprising the channels.

91. Apparatus according to claim 89 ~~or claim 90~~ wherein the density of said holes is sufficient to hold said plate flat against said flat surface.

92. Scanning apparatus, for writing a pattern on a surface, comprising:

a beam, modulated by data;

a rotating polygon, comprising a plurality of facets that move as the polygon rotates;

a first optical system that focuses the beam at least in a cross-scan direction, on a facet, such that the beam is angularly scanned in a scan direction, as the polygon rotates;

a second optical system that receives the beam and focuses it on the surface, such that wobble of the polygon does not transfer as cross-scan deviations to the surface.

93. Scanning optics according to claim 92 wherein the beam is defocused in the scan direction on the polygon.

94. Scanning optics according to claim 92 ~~or claim 93~~ wherein the beam is focused in both scan and cross-scan directions on the surface.

95. Scanning apparatus according to claim 92 ~~any of claims 92-94~~ wherein the second optical system transforms the angular sweep of the beam into a lineal sweep on the surface.

96. Scanning apparatus according to claim 92 ~~any of claims 92-95~~ wherein the second optical system introduces systematic deviations in the cross-scan direction as a function of its position in the scan direction; and

a data source that changes the data modulating the beam to compensate for the cross-scan deviations.

97. Scanning apparatus for writing a pattern on a surface in a series of passes, comprising:

at least one beam, modulated by at least one data signal;

a rotating polygon, comprising a plurality of facets that move as the polygon rotates;

an optical system that receives the at least one beam and focuses it on the surface, such that a pattern is written on the surface by the at least one beam, wherein the optical system introduces systematic deviations in the cross-scan direction as a function of its position in the scan direction; and

a data source that changes the data modulating the beam to compensate for the cross-scan deviations.

98. Apparatus according to ~~claim 96~~ or claim 97 and including:

a multi-channel optical modulator that receives at least one beam, and modulates the at least one beam to form the modulated beam.

99. Apparatus according to claim 98 and including a data store which stores a plurality of lines of data, said plurality of lines being greater than the number of independently modulated channels of the modulator and wherein data is sent to the modulator to modulate the beam from a line in response to the cross-scan deviation.

100. Apparatus according to claim 99 wherein the data store also stores the dependence of the cross-scan deviation with scan position.

101. Apparatus according to claim 99 ~~or claim 100~~ wherein the at least one beam comprises a plurality of beams.

102. Apparatus for writing a pattern on a radiation sensitive surface, comprising:

at least one laser beam having a predetermined intensity;

a modulator that receives the at least one beam at an input thereof and produces at least one modulated beam at an output thereof, and

a scanner that scans the at least one modulated beam across the surface with a scanning velocity within a scan velocity range in a plurality of successive, partially overlapping swaths having a variable overlap within a range of overlaps,

wherein the overlap and the scanning velocity are separately controllable, such that a range of power levels greater than that possible with either the range of overlaps or than the range of velocities may be delivered to the surface.

~~103. An acousto-optic modulator comprising:~~

~~an input surface at which a beam enters the modulator, at which surface the beam is refracted by a first angle that is a function of the wavelength of the beam and the angle of incidence of the beam on the input surface;~~

~~an output surface at which the beam exits the modulator, at which surface the beam is refracted by a second angle that is a function of the wavelength of the beam and the angle of incidence of the beam on the output surface;~~

~~an acousto-optic Bragg diffracting region in which the beam is diffracted by a third angle when an acoustic wave is present, the third angle being a function of the wavelength of the beam,~~

~~wherein at least the angle between the input and output surface is such that two input beams having given, different wavelengths, that are incident on the input surface at the same angle exit the output surface at the same angle.~~

104. Scanning apparatus, for writing a pattern on a surface, comprising:

a beam comprising energy at two distinct spectral lines, modulated by data; and

an optical system that receives the beam and focuses it on the surface, such that a pattern is written on the surface by the at least one beam and such that the energy at both spectral lines is focused on the surface at the same position.